

13/ARTS

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SPECIFICATION

METHOD AND APPARATUS FOR MOLDING BEAD

1. Field of the Invention

The present invention relates to a method and an
5 apparatus for molding a bead. More particularly, the
present invention relates to a method for molding the
hollow bead into an irregular shape from a highly viscous
material or a foamable material and a method for molding
the foamed bead covered with a highly viscous material into
10 an irregular shape as well as to an apparatus for molding
such a hollow bead and foamed bead.

2. Description of the Related Art

Japanese Patent Application Laid-open No. 3-178,362
discloses a method and an apparatus for applying and
15 molding a highly viscous material into foamed hollow bead
(each having a hollow foamed portion raised in a linear
fashion) or foamed bead with their sections being
expandable.

The applying and molding apparatus disclosed in this
20 prior patent application uses a mixer of a low energy
consumption type for reducing heat generation and includes
a mixing device that mixes feed gases in a pressurized
state into the highly viscous material and feeds a foamable
material with the highly viscous material dispersed in
25 minute particles. The applying and molding apparatus
further includes a discharging device that foams the
foamable material fed from the mixing device by discharging
it onto a work surface and forms a hollow bead in a tubular

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shape. As shown in Fig. 13, the discharging device includes a nozzle for discharging the foamable material comprised of a mixture of the highly viscous material with the pressurized gases and a plunger disposed so as to be
5 slidable in a direction (as indicated by symbol P) along an inner hole of the nozzle by means of a compression air piston (not shown).

Further, the inner hole of the nozzle of the applying device has a channel and a tapered wall section, the
10 channel being disposed for carrying the foamable material fed to the nozzle to an orifice located at a tip section of the nozzle and the tapered wall section forming an inner wall portion extending from the end of the channel to the orifice thereof. On the other hand, the plunger includes a
15 head portion in the form of an inverse truncated cone and a sectionally circular tip portion, the bottom portion being disposed so as to block the nozzle by close abutment with the tapered wall section and the sectionally circular tip portion being formed by cutting off the conical top section
20 thereof while remaining a small portion with the cut top rendered flat.

As the plunger is located in the position as indicated in Fig. 13 and the nozzle is open, the foamable material fed to the nozzle from the mixing device travels
25 through the channel in the direction as indicated by symbol Q in the drawing. The foamable material flows along the side surface of the truncated-conical head portion of the plunger in a pressurized state up to the circular tip

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portion thereof. Once the foamable material reaches the circular tip portion of the plunger, the pressure of the foamable material is caused to drop rapidly through the channel because no plunger exists in the channel ahead of the circular tip portion and the sectional path area of the channel increases rapidly. Therefore, the rapid drop of the pressure of the foamable material causes a central area of the channel immediately under the circular tip portion, as shown in the drawing, to an area where the pressure drops. Within the pressure drop area of the channel, the foamable material is allowed to be formed into small masses as gaseous cores, where the gases mixed with the foamable material have been released outside from the mixture or brought into a state where they are likely to be released outside therefrom.

The remaining and surrounding portion of the foamable material, where no such gaseous cores are formed, foams into gaskets upon the discharge from the orifice and the rapid reduction in pressure of the foamable material up to atmospheric pressure. As the foamable material is being fed and the foaming is being carried out continually, the highly viscous polymer material forms an extruded bead in a tubular shape. On the other hand, the gaseous cores of the foamable material formed in the pressure drop area of the channel are allowed to foam at an early stage, for example, even during the course of the foamable material travelling through the nozzle, while being flown along the axis of the tubular bead. The gaseous cores in the central portion of

the tubular bead are allowed to foam earlier than the mixture at the surrounding portion, so that the central portion of the tubular bead is formed into a hollow bead in tubular shape, while the mixture at the surrounding portion
5 foams.

The hollow tubular bead can completely seal, for example, a gap between an aperture and an opening/closing member by applying the contact portion thereof with them to block the gap. Further, the hollow tubular bead can
10 provide the various advantages that the hollow structure of the tubular bead can increase the strength of the tubular bead itself and reduce the compressive stress upon closure of the aperture with the opening/closing member.

The prior art technology disclosed in the published
15 patent application, however, has the defect that it requires complicated and large equipment for the preparation of a mixture of a highly viscous material with gases.

Furthermore, the prior art technology has the
20 structure that a flow of the gaseous cores formed in the pressure drop area of the channel are likely to be influenced largely by the flow characteristics of the foamable material. Therefore, it also suffers from the disadvantage that it is extremely difficult to align the
25 hollow portion of the tubular bead regularly in the axis thereof. If the flow path of the foamable material would be curved or the flow of the foamable material would become irregular, for example, the gaseous cores do not always

flow along the axis of the tubular bead so that there may be the occasion that the hollow portions of the tubular bead extending along the axis thereof are not formed in an ideal shape as intended. In addition, there may be the
5 occasion that the resulting bead may be rendered poor in quality because a larger hollow portion may be formed if the gaseous core would be penetrated into the surrounding area of the tubular bead and then foam therein.

SUMMARY OF THE INVENTION

10 Therefore, the present invention has been accomplished in order to overcome or improve the foregoing defects present in the prior art technology, and it has the object to provide a method for molding a bead and an apparatus for carrying out the method for molding the bead,
15 which can more stably mold the hollow bead or foamed bead of high quality having the advantages that they are low in compressive stress, lightweight, and high in strength, as comparable to conventional hollow bead and that they have little or no defective portion.

20 The present invention has another object to provide a bead-molding method and apparatus so adapted as to comply with a large-scale production and flexible applications to versatile usages by readily allowing the bead to be automatically applied and molded into an irregular form
25 onto a work, while conventional technology has otherwise applied manually a work with a foamed molding tape or a regular form of hollow tubular bead.

Further, the present invention has another object to

provide a method and an apparatus for molding the bead, which can accomplish each of the above objects of the present invention in a very simplified manner and structure.

In order to achieve the objects, the present invention in a first aspect provides a method for molding the hollow bead into a predetermined shape from a highly viscous material that is fluid in a high-speed flow region and high in the ability of retaining the shape into which it is located in a low-speed flow region, the bead-molding method comprising a gas stream forming step for forming a gas stream flowing in a one direction; a material stream forming step for forming a high speed flow of a highly viscous material stream in an outer peripheral space enclosing the gas stream; and a hollow bead molding step for molding the hollow bead into an irregular shape by reducing the high speed flow of the highly viscous material stream to its low speed flow, while fluidizing the highly viscous material flowing in the outer peripheral space outside the gas stream.

In the first aspect of the present invention, the gas stream flowing in the one direction is created in the gas stream forming step, and the highly viscous material stream flowing at a high speed flow through the outer peripheral space enclosing the gas stream is created in the material stream forming step. The highly viscous material stream is highly fluid or flowable when it is located in the high speed flow region, so that it can be molded into any optional form in a more flexible manner in the outer

peripheral space enclosing and about the gas stream, for example, by changing the direction of the highly viscous material stream. It is preferred, however, that the direction of the highly viscous material stream is the
5 direction substantially parallel to the direction in which the gas stream flows, to say, in substantially the same direction.

In the hollow bead molding step in the first aspect, the highly viscous material stream flowing in the high-
10 speed flow region can be molded into a given shape in a flexible manner by taking advantage of the fluidity of the highly viscous material, and the shape of the highly viscous material stream into the highly viscous material was applied and molded is retained as it is as the high
15 speed flow of the highly viscous material stream is dropped to the low-speed flow region and eventually to zero. At this instance, the gas stream flows at the central portion while fluidizing the highly viscous material into an irregular shape so as to maintain the status in which the
20 highly viscous material is flowing around the gas stream. This configuration can mold the hollow bead into any optional shape that has its inner portion rendered hollow and the surrounding portion enclosed with the highly viscous material. This bead-molding step can readily mold,
25 for instance, hollow bead in a slenderly elongated tubular form and curved hollow bead.

The present invention in a second aspect provides a method for molding a hollow bead from a foamable material

for molding a foamed body, which comprises a gas stream forming step for forming a gas stream flowing in a one the direction; a material stream forming step for forming a highly viscous material stream in an outer peripheral space enclosing the gas stream, the highly viscous material stream flowing in the same direction as the direction of the gas stream; and a hollow bead molding step for molding the hollow bead into an irregular shape while foaming the foamable material flowing through the outer peripheral space.

In the second aspect of the present invention, the hollow bead can be molded into any optional shape by the processes similar to the above processes in the first aspect, the hollow bead having its inside rendered hollow and its surrounding portion enclosed with the foamed body.

The present invention in a third aspect provides a method for molding the hollow bead into a shape of the applying position by applying the hollow bead on the work while following the work, in the hollow bead molding step in the first and second aspects, respectively.

In the third aspect of the present invention, as the highly viscous material stream or the foamable material stream in the high speed flow region reaches the applying position, the flow speed of the material stream is rapidly reduced up to a low speed and eventually to zero. At the same time, the viscosity of the material stream is caused to increase rapidly and assumes a certain shape, to say, a shape that the highly viscous material stream or the

foamable material stream encloses the gas stream.

Furthermore, the highly viscous material stream or the foamable material stream is set into that shape. As the highly viscous material stream or the foamable material

5 stream is transferred in this state along and following the shape of the applying position, the material is applied and molded into the shape that complies with the shape of the applying position.

Upon applying the material on the work, the hollow
10 bead applied and molded can be tackied or adhesived to the work by using the highly viscous material or the foamable material having an tackinessly or adhesive property, as in a fourth aspect of the present invention.

Further, in order to form the one-way flow of the gas
15 stream and the material stream flowing around the gas stream, a discharging device may be arranged and configured as in a fifth aspect of the present invention so as to perform the methods as configured in the first to fourth aspects as described above. The discharging device has an
20 inner nozzle elongated at a tip portion and an outer nozzle elongated so as to enclose an outer periphery of the inner nozzle. In this aspect, the gas stream forming step is preferably configured such that the gas stream is allowed to flow in a one direction by discharging gases from the
25 inner nozzle, and the material stream forming step is preferably configured discharging the highly viscous material or foamable material stream from the outer nozzle to form the material stream outside and around the gas

stream in the same direction as the gas stream flows.

Moreover, in a sixth aspect as a preferred configuration of the third or fourth aspect as described above, a discharging device is provided which has an inner
5 nozzle elongated at a tip portion and an outer nozzle elongated so as to enclose an outer periphery of the inner nozzle in order to the method in the third or fourth aspect of the present invention. In the gas stream forming step, gases are discharged from the inner nozzle to form a gas
10 stream flowing in a one direction. On the other hand, in the material stream forming step, the highly viscous material or the foamable material is discharged from the outer nozzle in the form of a stream that flows in the same direction as the gas stream flows while enclosing the gas
15 stream. Further, in the bead molding step, the hollow bead is applied and molded into a shape corresponding to the shape of the applying position by transferring the inner nozzle and the outer nozzle along a predetermined locus following the shape of the applying position while
20 discharging the highly viscous material or the foamable material onto the work.

In accordance with the present invention, the gas stream is formed to flow in the one direction and the highly viscous material stream is formed to flow in a high
25 speed flow region about and enclosing the gas stream, while the highly viscous material stream is molded into a predetermined shape while slowing the high speed flow of the highly viscous material stream down to the low speed

flow as the highly viscous material is being rendered fluid. Therefore, this aspect of the present invention can present the advantages that the hollow bead of high quality can be molded into an optional shape without any or less defects in a ready and stable manner. Moreover, the hollow bead can provide a sealing portion having an appropriate level of elasticity because they are hollow inside so that they are lightweight and they require only a small amount of stress upon compression.

10 It is noted herein, however, that the method for molding the hollow bead in the aspects as described above can also be applied to a seventh aspect and subsequent aspects where a foamed bead with its inner portion filled with a foamable material and its surrounding and outer
15 portion covered or applied with the highly viscous material.

 In a seventh aspect of the present invention, there is provided a bead-molding method for molding the foamed bead into a given shape from a foamed body covered with the highly viscous material that is fluid in the form of a
20 stream in a high speed flow region and can retain its shape into which the highly viscous material is applied when it is in a low speed flow region. The bead-molding method in this aspect is composed of a foamable material stream forming step for forming a foamable material stream flowing
25 in a one direction, which can forms the foamed body; a material stream forming step for forming a highly viscous material stream in a high speed flow region within an outer peripheral space enclosing and about the foamable material

stream; and the bead molding step for molding the foamed bead into an irregular shape by reducing the high speed flow of the highly viscous material to the low speed flow thereof while fluidizing the highly viscous material
5 flowing around and about the foamable material stream and, at the same time, by foaming the foamable material.

In an eighth aspect, the foamed bead are molded into a given shape along and following the shape of the work by transferring the work along its shape while applying the
10 work with the foamable material stream and the highly viscous material stream, in accordance with the seventh aspect.

The present invention in a ninth aspect is directed to the bead-molding step wherein the foamed bead applied
15 and molded is tackied or adhesived to the work by using the highly viscous material having an tacky or adhesive property tackiness.

In a tenth aspect of the present invention, the bead-molding method in one of the seventh to ninth aspects is
20 modified in such a manner that the discharging device is disposed which has an inner nozzle elongated at its tip portion and an outer nozzle elongated about and enclosing the outer periphery of the inner nozzle; the foamable material stream flowing in the one direction is formed by
25 discharging the foamable material from the inner nozzle in the foamable material stream forming step; and the highly viscous material stream flowing in the same direction as the foamable material stream and about and enclosing the

foamable material stream by discharging the highly viscous material from the outer nozzle in the material stream forming step.

5 The present invention in an eleventh aspect is directed to the bead-molding method modified from the method in the eighth or ninth aspect, which includes a discharging device having an inner nozzle elongated at its tip portion and an outer nozzle elongated about and enclosing the outer periphery of the inner nozzle; the
10 foamable material stream forming step for forming the foamable material stream flowing in the one direction by discharging the foamable material from the inner nozzle; the material stream forming step for forming the highly viscous material stream flowing in the same direction as
15 the foamable material stream and about and enclosing the foamable material stream by discharging the highly viscous material from the outer nozzle; and the bead molding step for molding the foamed bead into a given shape corresponding to the shape of the work by transferring the
20 discharging device along a predetermined locus following the shape of the work while discharging the foamable material stream and the highly viscous material stream from the inner nozzle and the outer nozzle, respectively, onto the work.

25 In accordance with any one of the seventh to eleventh aspects of the present invention, there are formed the foamable material stream flowing in the one direction and the highly viscous material stream flowing in the high-

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speed flow region while enclosing the foamable material stream in such a way that the foamed bead are molded by transferring the highly viscous material stream in the high-speed flow region to the low-speed flow region while rendering the highly viscous material fluid. Therefore, the method according to this aspect can present the advantages that the foamed bead of high quality can be molded into an optional shape without any or less defects in a ready and stable manner. Moreover, the foamed bead is of a hollow foamed body so that the foamed bead can provide a sealing section that is lightweight, has a small stress against compression as well as an appropriate level of softness. Furthermore, the foamed bead can provide the foamed body with improved waterproof, airtight and shock absorbing performance, as compared with a foamed body made of a conventional bead that is not covered or enclosed with any highly viscous material.

Further, the discharging device in the sixth or eleventh aspect can be used as a system for automatically applying and molding the hollow bead or the foamed bead. Moreover, as in a twelfth aspect, the discharging device can be mounted on a manipulator disposed movable to a desired position in response to a control signal, and the bead-molding step is arranged to automatically apply and mold the hollow bead or the foamed bead on the work of plural work members one after another being carried on a manufacturing line by controlling the discharging position of the discharging device by means of the manipulator.

Furthermore, in the twelfth aspect, it is preferred to control the manipulator so as to bring the actually applying position of work the bead by the discharging device substantially into agreement with a predetermined target applying position by detecting the actual applying position thereof, as in a thirteenth aspect of the present invention. This control enables applying the hollow bead or the foamed bead at the accurate positions following the work.

Moreover, in the twelfth or thirteenth aspect, it is preferred to automatically decide whether the bead is applied and molded in a favorable fashion by picking up an image of the bead applied and molded in a favorable fashion and comparing the picked-up image of the bead with a pre-stored reference image of the bead applied and molded in a favorable fashion, as in a fourteenth aspect,

By enabling the automatic decision on the bead molded in a favorable fashion, the operator can immediately determine the bead with defects so that he can carry out the subsequent proceeding without delay.

Further, in any one of the twelfth to fifteenth aspects, it is preferred to use an opening closing member capable of opening and closing a given opening as the work member as in a fifteenth aspect.

In the fifteenth aspect, it is further preferred to apply and mold the hollow bead or the foamed bead on the work and form a sealing section between the opening and the opening/closing member, as in a sixteenth aspect, the work

being a site nearby and along the edge portion of the opening/closing member.

In the sixteenth aspect, a foamed body with the inside rendered hollow or rich of gaseous bubbles is used, so that the sealing section becomes lightweight and has a small amount of stress against compression as well as has an appropriate level of elasticity. These properties can provide the sealing section with improved sealing performance when the opening/closing member is closed and provide for the easy operations for opening and closing the opening/closing member.

As described above, in each of the twelfth to sixteenth aspects of the present invention, the hollow bead or the foamed bead can be applied and molded into any optional shape on the work automatically, so that the bead-molding method according to the present invention can deal with a large-scale production of molded members and versatile requirements for applications.

Then, a description will be given below regarding a bead-molding apparatus for conducting the bead-molding method as in the following seventeenth to thirtieth aspects of the present invention.

For the bead-molding apparatus for molding the hollow bead as in the seventeenth aspect of the present invention, the apparatus includes a discharging device having an inner nozzle elongated at its tip portion, an outer nozzle elongated about and enclosing an outer periphery of the inner nozzle, a first inlet connecting with the inner

nozzle, and a second inlet connecting with the outer
nozzle; a gases feed unit for feeding gases to the
discharging device through the first inlet; and a material
feed unit for feeding a highly viscous material or a
5 foamable material to the discharging device through the
second inlet, the highly viscous material being fluid in
the form of a stream in a high speed flow region and
capable of retaining the shape into which the material is
molded. As in the seventeenth aspect of the present
10 invention, the apparatus of molding the hollow bead can be
realized in such a very simple structure.

In the eighteenth aspect, the bead-molding apparatus
of the present invention includes discharging device
including an inner nozzle disposed extending at a tip
15 portion, an outer nozzle disposed extending about and
enclosing an outer periphery of the inner nozzle, a first
inlet connecting with the inner nozzle, and a second inlet
connecting with the outer nozzle; a foamable material feed
unit for feeding a foamable material to the discharging
20 device through the first inlet; and a material feed unit
for feeding a highly viscous material to the discharging
device through the second inlet, the highly viscous
material being fluid in the form of a stream in a high
speed flow region and capable of retaining a shape into
25 which it is molded in a low speed flow region.

For the foamable material feed unit in the eighteenth
aspect, it is preferred to feed a mixture of gases with the
highly viscous material as the foamable material, as in a

nineteenth aspect.

As in a twentieth aspect of the present invention, the foamable material feed unit in the nineteenth aspect includes a plurality of piston pumps arranged so as to perform an suction stroke and a extrusion stroke by reciprocally moving a piston in a cylinder; a foaming gas injection unit for injecting gases under a predetermined pressure into the cylinder; and a pump control unit for controlling the plurality of the piston pumps in such a manner that each of the plurality of the piston pumps is arranged to conduct the suction stroke for feeding gases and with the highly viscous material after the suction stroke and to conduct the extrusion stroke for discharging the mixture of the gases with the highly viscous material as the foamable material as well as that a time difference is provided for the extrusion stroke of each of the plurality of the piston pumps so as to continually discharge a predetermined quantity of the foamable material.

In the present invention in the twentieth aspect, the cylinder pump of a predetermined flow amount are used, and the gases are first introduced followed by the introduction of the highly viscous material, so that the pressure of the gases can be rendered lower and the highly viscous material can be mixed with the gases at an accurate mixing rate. Furthermore, the plural cylinder pumps each having a predetermined flow amount are arranged with a time difference so that they can discharge the mixture continually at a predetermined quantity in accordance with

given control procedures, thereby enabling applying and molding the foamed bead in a uniform and even manner.

Further, in a twenty-first aspect of the present invention, the foamable material feed unit is further
5 provided with a dispersing tubular path for dispersing gaseous bubbles in minute at a discharging process.

Moreover, in the twenty-first aspect, as the mixture is passing through the dispersing tubular path, a relative speed difference is caused to occur between the central
10 portion and the peripheral portion, i.e., a portion close to the inner wall section of the tubular path. This relative speed difference assists in dispersing the gaseous bubbles in the mixture into more fine particle and this mechanism can further improve the quality of the foamed
15 bead.

In the present invention in a twenty-second aspect, the discharging device as in each of the seventeenth to twenty-first aspect is configured such that a variation of each of the inner nozzle and the outer nozzle in the inner
20 wall diameter becomes smaller over the length extending from the connection end section with the body of the discharging device to the tip portion with a predetermined inner dimension.

In the twenty-second aspect of the present invention,
25 the variation in the inner wall diameter is defined to become smaller, so that a loss in pressure of the material stream within the nozzle can be minimized under the given conditions of the nozzle size.

A twenty-third aspect of the present invention is characterized by the inner nozzle and the outer nozzle of the discharging device in each of the seventeenth to twenty-second aspects, each of which has the outer nozzle wall portion containing the outermost edge section comprised of an slant surface joining at an acute angle with respect to the direction in which the highly viscous material or the foamable material is discharged.

More specifically, in the twenty-third aspect, the
10 outer wall portion of the nozzle containing the outermost
edge section is inclining at an acute angle with respect to
the flow of the material stream, so that the material
becomes unlikely to be adsorbed at the outer nozzle wall
portion while the material is being discharged from the
15 nozzle outlet.

In a twenty-fourth aspect, the present invention in each of the seventeenth to twenty-third aspect is characterized by a first control valve and a second control valve for controlling the opening and closing of the passages extending from the first inlet to the inner nozzle and from the second inlet to the outer nozzle, respectively, the first and second control valves being disposed in the corresponding passages.

The first and second control valves in this aspect
25 may be opened and closed, for example, by a pneumatic
cylinder, a hydraulic cylinder or an electrically-drivable
motor.

Further, in a twenty-fifth aspect, the discharging

device in the twenty-fourth aspect can be hand-carried and the first and second control valves can be opened and closed by manual on-off operations.

These configurations allow the operator to operate
5 the bead-molding apparatus manually. Therefore, the hollow bead or the foamed bead can be applied without much difficulty even at a very narrow place where a large-size manipulator cannot be used for application and so on.

Moreover, in order to automatically control the
10 discharging of the bead by the discharging device, a twenty-sixth aspect of the present invention is configured such that the first and second control valves as in the twenty-fourth aspect is arranged so as to be opened and closed in response to an instruction signal.

15 The present invention in a twenty-seventh aspect is characterized in that the discharging device in the twenty-sixth aspect is mounted on a top portion thereof and is further provided with a manipulator disposed so as to be movable to a desired position in response to a control
20 signal and with a control unit for automatically control the movement of the manipulator and the discharging of the discharging device in accordance with a predetermined program.

In a twenty-eighth aspect, the control unit in the
25 twenty-seventh aspect is arranged so as to automatically control the movement of the manipulator and the discharge of the discharging device so as to automatically apply and mold the hollow bead or the foamed bead on a work of each

of a plurality of work members being carried on a manufacturing line one after another.

The present invention in the twenty-eighth aspect can realize a system suitable for automatically applying and molding the hollow bead or the foamed bead of high quality on the work members on a large scale.

Further, in the twenty-eighth aspect, it is preferred as in a twenty-ninth aspect of the present invention that that the discharging device is further provided with a detection unit for detecting an actual applying position of work the bead by the discharging device and that the control unit is arranged to control the manipulator so as for the actual applying position thereof to be brought substantially into agreement with a predetermined target on the work.

Moreover, as in a thirtieth aspect, it is preferred that the apparatus in the twenty-ninth aspect is further provided with an image pick-up unit for picking up an image of the bead applied and molded on the work and that the control unit is arranged to automatically decide whether the bead is applied and molded in a favorable fashion by comparing the picked-up bead image with a pre-stored reference image of the bead applied and molded in a favorable fashion.

It is to be noted herein that the present invention in each of the above aspects can be extended to a method and an apparatus wherein a hot melt material is used whose fluidity can be controlled by temperature, in place of the

flow speed.

For instance, the present invention in a thirty-first aspect is directed to a bead-molding method for molding hollow bead from a hot melt material that is fluid in the form of a stream in a middle-high temperature region and can retain the shape into which the bead is molded in a middle-low temperature region, and the bead-molding method comprises a gas stream forming step for forming a gas stream flowing in a one direction; a material stream forming step for forming a hot melt material stream in the middle-high temperature region within an outer peripheral space about and outside so as to enclose the gas stream; and a bead molding step for molding the hollow bead into an irregular shape by cooling the middle-high temperature of the hot melt material to the middle-low temperature while fluidizing the hot melt material flowing in the outer peripheral space about the gas stream.

In the thirty-first aspect of the present invention, the gas stream is formed in the gas stream forming step and the stream of the hot melt material is formed in the outer peripheral side about and enclosing the gas stream in the material stream forming step. The hot melt material stream is highly fluid in the middle-high temperature region, so that the hot melt material can be applied and molded flexibly into a given shape by taking advantage of the high fluidity and molded into the given shape as it was by cooling the temperature of the hot melt material from the middle-high temperature region to the middle-low

temperature region.

It is to be noted herein that the middle-high temperature region as referred to herein means to include a temperature range from approximately 60°C (333 K) to approximately 200°C (473 K) and the middle-low temperature region as referred to herein means to include a temperature range from room temperature to approximately 150°C (423 K). Further, it is preferred that there is a temperature difference between the middle-high temperature region and the middle-low temperature region by approximately 5°C or higher.

It should further be noted herein that the present invention in the aspect relating to the hot melt material can also be used in a similar manner to a foamable hot melt material obtainable by foaming the hot melt material.

Therefore, the present invention in a thirty-second aspect is directed to a bead-molding method for molding the hollow bead from the foamable hot melt material for forming a foamed body, and the bead-molding method may comprises a gas stream forming step for forming a gas stream flowing in a one direction; a material stream forming step for forming the foamable hot melt material stream flowing in the same direction as the gas stream within an outer peripheral space about and outside so as to enclose the gas stream; and a bead molding step for molding the hollow bead into an irregular shape by foaming the foamable hot melt material flowing in the outer peripheral space about the gas stream.

In a thirty-third aspect, the present invention in

the thirty-first aspect or the thirty-second aspect is characterized in that the hollow bead are applied and molded into a shape corresponding to and following the shape of the work by transferring the hot melt material stream or the foamable hot melt material stream along and following the shape of the work while applying the material stream onto the work in the bead-molding step.

The present invention in a thirty-fourth aspect is characterized in that, in the thirty-third aspect, the discharging device is disposed which has an inner nozzle elongated at its tip portion and an outer nozzle elongated about and enclosing an outer periphery of the inner nozzle; the gas stream forming step is to form the gas stream flowing in a one direction by discharging the gases from the inner nozzle; the material stream forming step is to form the hot melt material stream or the foamable hot melt material stream in the same direction as the gas stream so as to enclose the gas stream by discharging the hot melt material or the foamable hot melt material from the outer nozzle; and bead-molding step for molding the hollow bead into a shape corresponding to and following the shape of the work by transferring the material stream along a given locus while discharging the gas stream and the material stream toward and onto the work from the respective inner and outer nozzles.

Moreover, the present invention in a thirty-fifth aspect is directed to a bead-molding method for molding a foamed bead comprised of a foamed body covered with a hot

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melt material that is fluid in the form of a stream in a middle-high temperature region and can retain the shape into which it is molded in a middle-low temperature region, and the bead-molding method comprises a foamable material stream forming step for forming a stream of a foamable hot melt material for forming the foamed body; a material stream forming step for forming a stream of the hot melt material flowing in the middle-high temperature region within an outer peripheral space the foamable hot melt material stream about and enclosing the foamable hot melt material stream; and a bead-molding step for molding the foamed bead into an irregular shape by cooling the middle-high temperature region to the middle-low temperature region while fluidizing the hot melt material stream flowing within the outer peripheral side outside and about the foamable hot melt material stream and foaming the foamable hot melt material.

In a thirty-sixth aspect, the present invention is characterized in that the bead-molding step in the thirty-fifth aspect is further arranged so as to mold the foamed bead into a shape corresponding to and along the shape of the work by applying the hot melt material stream or the foamable hot melt material stream onto the work while transferring the material stream along and following the shape of the work.

In a thirty-seventh aspect, the present invention in the thirty-fifth or thirty-sixth aspect is configured such that a discharging device is disposed which has an inner

nozzle elongated at a tip portion thereof and an outer
nozzle elongated about and enclosing an outer periphery of
the inner nozzle, wherein the foamable stream forming step
forms the foamable hot melt material stream in the one
5 direction by discharging the foamable hot melt material
from the inner nozzle; and the material stream forming step
forms the hot melt material stream in the same direction of
the direction of the foamable hot melt material stream and
enclosing the foamable hot melt material by discharging the
10 hot melt material from the outer nozzle.

The present invention in a thirty-eighth aspect
includes a discharging device including an inner nozzle
elongated at a tip portion thereof and an outer nozzle
elongated enclosing an outer periphery of the inner nozzle;
15 wherein the foamable stream forming step forms the foamable
hot melt material stream in the one direction by
discharging the foamable hot melt material from the inner
nozzle; the material stream forming step forms the hot melt
material stream in the same direction as the direction of
20 the foamable hot melt material stream by discharging the
hot melt material from the outer nozzle; and the bead
molding step for molding foamed bead into a shape
corresponding to and following the shape of the work by
transferring the material stream along a given locus while
25 discharging the foamable hot melt material from the inner
nozzle and the hot melt material the outer nozzle,
respectively.

Further, in a thirty-ninth aspect, the bead molding

method in the thirty-seventh or thirty-eighth aspect is characterized in that the discharging device is mounted on a manipulator disposed to be movable to a desired position in response to a control signal, and in the bead molding
5 step, the hollow bead or the foamed bead are automatically applied and molded on the applying position of a plurality of work members being carried on a manufacturing line one after another by controlling the discharging position of the discharging device by means of the manipulator.

10 The present invention in a fortieth aspect provides a bead molding apparatus for forming the hollow bead, which includes a discharging device comprised of an inner nozzle elongated at a tip portion thereof, an outer nozzle elongated about and enclosing an outer periphery of the inner
15 nozzle, a first inlet connecting with the inner nozzle, and a second inlet connecting with the outer nozzle; a gases feed unit for feeding gases to the discharging device through the first inlet; and a material feed unit for feeding a hot melt material or a foamable hot melt material
20 to the discharging device through the second inlet, the hot melt material being fluid in the form of a stream in a middle-high temperature region and can retain the shape into which the material is molded in a middle-low temperature region.

25 Moreover, the present invention in a forty-first aspect is directed to a bead molding apparatus for forming foamed bead and characterized in that the apparatus includes a discharging device comprised of an inner nozzle

system in accordance with a first embodiment of the present invention.

Fig. 2 is a sectional view showing an inner structure of a discharging device of the automatically bead applying and molding system in accordance with the first embodiment of the present invention.

Fig. 3 is a sectional view showing details of the structure of a nozzle and part around the nozzle of the discharging device of Fig. 2.

Fig. 4 is an exploded view showing parts of the nozzle of Fig. 3.

Fig. 5 is a block diagram showing a specific configuration of a highly viscous material feed unit for use with the automatically hollow bead applying and molding system according to the first embodiment of the present invention.

Fig. 6 is a block diagram showing a specific configuration of a gases feed unit for use with the automatically hollow bead applying and molding system according to the first embodiment of the present invention.

Fig. 7 is a view for description of a process for applying and molding the hollow bead; wherein (a) is a schematic view showing the applying and molding process and (b) is perspective and sectional views showing the hollow bead formed by the applying and molding process.

Fig. 8 is a plan view of opening/closing member for a control board as a work for applying the hollow bead by the automatically hollow bead applying and molding system

according to the first embodiment of the present invention; wherein (a) is directed to the control board before applying and (b) is directed to the control board after applying.

5 Fig. 9 is a view showing an outline configuration of an automatically foamed bead applying and molding system according to a second embodiment of the present invention.

10 Fig. 10 is a block diagram showing a specific configuration of a foamed material feed unit for use with the automatically foamed bead applying and molding system according to the second embodiment of the present invention.

 Fig. 11 is a timing chart showing the action timing of a cylinder pump of the foamed material feed unit as shown in Fig. 10.

15 Fig. 12 is an illustrative view showing a bead molding device according to a third embodiment of the present invention.

 Fig. 13 is a view showing the structure of discharging device for explaining prior art technology.

20 DESCRIPTION OF THE PREFERRED EMBODIMENTS

 The present invention will be described in more detail by way of embodiments with reference to the accompanying drawings.

First Embodiment:

25 Fig. 1 shows an outline configuration of a system for automatically applying and molding a hollow bead in accordance with the first embodiment of the present invention. The system is adapted to apply and mold the

hollow bead suitable on a large scale for use in automatically applying and molding the hollow bead along an edge portion of a work for a control board.

In Fig. 1, there is shown a system 1 for automatically applying and molding the hollow bead, which includes a discharging device 10 for discharging feed gases and a highly viscous material from a nozzle 12 to form a hollow bead, a gases feed section 14 for feeding the gases to the discharging device 10, a highly viscous material feed section 16 for feeding the high viscous material to the discharging device 10, the highly viscous material that is fluid in the form of a stream in a high speed flow region and can retain the shape into which it is molded in a low speed flow region, and a compressive air control section 18 for controlling the opening and closing of a discharging valve (as will be described later) disposed inside the discharging device 10 by feeding compressive air to the discharging device 10 and controlling the compressive air pressure therein.

In order to adapt the discharging device 10 to the automatic applying and molding on a large scale, the discharging device 10 is mounted on a tip portion of a manipulator 60 through a flange or any other suitable part, the manipulator 60 being arranged so as to transfer the tip portion thereof to a desired position located within a predetermined range in response to an control signal. The bead applying and molding system 1 may include a belt conveyor 65, a detection sensor 25, an image pick-up sensor

26, a controller 22, a memory unit 24, and an I/O port 20. The belt conveyor 65 can carry plural opening/closing member 23 loaded on an endless belt 67 one after another to the predetermined applying position in which the

5 opening/closing member 23 can be applied. The detection sensor 25 can detect the predetermined applying position in which the opening/closing member 23 loaded on the belt conveyor 65 is to be applied. The image pick-up sensor 26 can pick up images of the opening/closing member 23 and the

10 hollow bead applied and molded on the opening/closing member 23. The controller 22 can control and manage the entire operations of the bead applying and molding system 1. The memory unit 24 is to store data necessary for applying and molding the hollow bead. The I/O port 20 can control

15 input and output interfaces between the controller 22 and other structuring elements.

These structuring elements can be realized by known technology. For instance, the detection sensor 25 may be configured as a combination of a light emitting diode (LED)

20 capable of emitting light to the predetermined applying position with a phototransistor disposed so as to detect the light emitted from the LED. With this configuration of the detection sensor 25, the phototransistor can detect the blocking of the passage of the light from the LED by the

25 work 23 so that the blocking of the light passage may be determined as the location of the work 23 in the predetermined applying position. Further, the image pick-up sensor 26 may be comprised of a CCD (charge coupled

device). Moreover, the controller 22 may be composed of a micro-processor or a personal computer, for example, which can carry out various kinds of processing including image analysis using CCD images and a so-called PI (proportional-plus-integral) control.

Next, a description will be given regarding the detailed structure of the discharging device 10 with reference to Figs. 2 to 4.

Fig. 2 shows a sectional view showing the discharging device 10. As shown in Fig. 2, the discharging device 10 has a discharging unit for discharging a highly viscous material, including a pneumatic cylinder 13 disposed in a body 33 thereof, a piston 17 disposed to reciprocally move within the pneumatic cylinder, a rod 19 elongated from a surface at the nozzle side of the piston, a material inlet 11a connected to the highly viscous material feed section 16 (Fig. 1), a material chamber 27 for storing the highly viscous material fed from the material inlet before discharging, a valve path 28 formed from and through a side portion of the chamber at its nozzle side, an inner material path 29 branched from the valve path up to a base portion of the nozzle 12, and a material nozzle line 31 elongated from the inner material path 29 up to a tip portion of the nozzle.

The body 33 of the discharging device 10 has compressive air pressure feed inlets 15a and 15b through which compressive air pressure is fed from the outside into the body thereof. The feed inlets 15a and 15b are disposed,

respectively, connecting with positions close to the top
dead center of the pneumatic cylinder 13 and the bottom
dead center thereof. The compressive air pressure feed
inlets 15a and 15b are connected to the compressive air
5 pressure control section 18 (Fig. 1) through a pneumatic
line and controlled to feed air from the compressive air
pressure control section 18. As the compressive air
pressure fed to the compressive air pressure feed inlet 15a
is decreased while the compressive air pressure fed to the
10 compressive air pressure feed inlets 15b is increased, the
piston 17 is moved in the direction indicated by arrow P
and reaches the top dead center. On the contrary, as the
compressive air pressure fed to the compressive air
pressure feed inlet 15a is increased while the compressive
15 air pressure fed to the compressive air pressure feed
inlets 15b is decreased, the piston 17 is moved in the
direction indicated by arrow Q and reaches the bottom dead
center. As described above, the piston 17 is controlled by
the compressive air pressure control section 18 so as to
20 reciprocally move between the top dead center and the
bottom dead center of the pneumatic cylinder 13.

The rod 19 is disposed in a rod hole 35 extending and
connecting between the pneumatic cylinder 13 and the
material chamber 27 inside the body portion, and a tip
25 portion of the rod 19 is elongated in the material chamber
27. As the piston 17 moves in the direction P and
approaching the top dead center, the tip portion of the rod
19 is allowed to enter into the valve path 28 and assume

the state as indicated in Fig. 2, thereby blocking the passage of the highly viscous material from the material chamber 27 to the nozzle 12. In other words, the highly viscous material fed is caused to stay within the material chamber 27 and cannot be discharged from the nozzle 12. On the other hand, as the piston 17 moves in the direction Q and approaching the bottom dead center, the tip portion of the rod 19 is released from the valve path 28 and the passage of the highly viscous material from the material chamber 27 to the nozzle 12 is opened. Therefore, the highly viscous material fed can be discharged from the material chamber 27 through the inner material path 29 and the nozzle line 31 into the nozzle 12, followed by discharging the highly viscous material from the nozzle 12.

15 The discharging device 10 has a gas discharging unit including a gas inlet 11b connected to the gas feed section 14 (Fig. 1) for receiving the supply of gases therefrom, an inner gas path 30 for allowing the passage of the gases fed from the gas inlet 11b within the body thereof, and a gas nozzle line 32 disposed in the nozzle 12 and connected to the inner gas path 30. The inner path of the gas inlet 11b is provided with a gas control valve 11c for controlling the opening and closing of the gas inlet 11b. As the gas control valve 11c is opened, the gases fed from the gas feed section 14 are discharged from the tip of the nozzle 12 through the inner gas path 30 and the gas nozzle line 32. On the contrary, although a matter of course, as the gas control valve 11c is closed, the gases fed therefrom are

not discharged from the nozzle 12. The gas control valve 11c may be controlled so as to be opened and closed by means of an electrically-driven motor (not shown) or any other suitable unit.

5 Further, the discharging device 10 is provided with a flange 34 at its rear end portion, and the discharging device 10 is mounted on the manipulator 60 through the flange 34.

10 Fig. 3 shows the details on the sectional view of the nozzle 12. As shown in Fig. 3, the nozzle 12 is of a double nozzle structure consisting of an inner nozzle 36 elongated slenderly over the entire length thereof so as to allow discharging the gases in the one direction, and an outer nozzle 38 elongated slenderly over the entire length
15 thereof so as to allow discharging the highly viscous material in a pressured state in the one direction. The gas nozzle line 32 is disposed inside the inner nozzle 36, and the material nozzle line 31 is interposed between the outer wall of the inner nozzle 36 and the inner wall of the
20 outer nozzle 38 enclosing the material nozzle line 31. In order to reduce a loss in pressure upon the supply of the highly viscous material under pressure, the inner wall of the material nozzle line 31 is rendered very smooth and is formed so as to make a variation in inner line dimension
25 smaller. In order to do this, for instance, the inner wall of the material nozzle line 31 may be formed so as to compensate the difference in dimension between the size of the nozzle at its tip predetermined to adapt to the size of

the hollow bead and the size of a connection portion
between the nozzle 12 and the body 33 for a fine variation
in dimension at any portion of the nozzle over its entire
nozzle length. The gas nozzle line 32 is set to become
5 identical in size over the entire nozzle length.

Moreover, the outer nozzle 38 is provided with a
slanting surface 39 so as to intersect with an outer wall
portion extending rearward from the outermost tip at an
acute angle with respect to the direction of discharging
10 the highly viscous material. On the other hand, the inner
nozzle 36 is provided with a slanting surface 37 so as to
intersect with an inner wall portion extending rearward
from the outermost tip thereof at an acute angle with
respect to the direction of discharging the highly viscous
15 material. As these slanting surfaces 37 and 39 are formed
each at an acute angle with respect to the direction in
which the highly viscous material stream discharged from
the outer nozzle 38 flow, an occurrence of dragging of the
highly viscous material due to the high viscosity of the
20 highly viscous material attached to the discharging outlet
can be prevented, thereby resulting in the reduction in a
loss in pressure.

As shown in Fig. 3, each of the discharging paths 31
and 32 of the nozzle 12 is of coaxially circular form in
25 section when taken in the direction perpendicular to the
axis of the nozzle.

Fig. 4 shows parts of the nozzle 12. As shown in Fig.
4, a structuring portion containing the inner nozzle 36 and

the outer nozzle 38 may be divided into tow structuring parts, one structuring part being as an inner nozzle part 45a and an outer nozzle part 45b. The inner nozzle part 45a may be composed of the inner nozzle 36 in the form of a truncated cone and a flange portion 42 connecting the inner nozzle 36 to the body 33. The flange portion 42 may include a plurality of apertures 40 through which the highly viscous material can be discharged to the material nozzle line 31 when they are aligned with a plurality of apertures of the inner material path 29 and further include a raised portion 46 and two cut portions 41 and 41, the raised portion 46 being raised from the flange portion 42 so as to engage with the base section of the outer nozzle 38 and the two cut portions 41 and 41 being formed in the raised portion 46.

On the other hand, the outer nozzle part 45b includes the outer nozzle 38 in the form of a truncated cone with its inside rendered hollow, a flange portion 43 formed at the base section of the nozzle, and two projection portions 44 and 44 formed projecting inwardly from the inner periphery of the flange portion 43.

The outer nozzle part 45b is joined with the inner nozzle part 45a by aligning the two projection portions 44 and 44 of the flange portion 43 of the outer nozzle part with the corresponding cut portions 41 and 41 of the inner nozzle 45a. As the inner nozzle part 45a is joined with the outer nozzle part 45b, the inner nozzle 36 is covered as a whole with the outer nozzle 38, and the material

nozzle line 31 is defined as a space or clearance between the outer wall of the inner nozzle 36 and the inner wall of the outer nozzle 38. Therefore, the material nozzle line 31 is disposed about and enclosing the gas nozzle line 32.

5 The highly viscous material feed section 16 of Fig. 1 can be realized in a very simple configuration as shown in Fig. 5. In Fig. 5, the highly viscous material feed section 16 may comprise a storage can 47 for storing the highly viscous material, a pump 48 for discharging a given
10 flow amount of the highly viscous material stored in the storage can 47, a valve 49 for opening and closing a path through which the highly viscous material stream discharged flows, a check valve 50 for preventing a return flow of the highly viscous material stream, and a tubular line 51
15 connected to the material inlet 11a of the discharging device 10. The pump 48 may include, for example, a plunger pump of a floor plate type.

It is to be noted herein that the highly viscous material to be stored in the storage can 47 may preferably
20 include a highly viscous material selected from highly viscous materials that are fluid and flowable and have a low dynamic viscosity in a high speed flow region, on the one hand, and have a high static viscosity and has the high ability to retain the shape into which it is molded in a
25 low speed flow region, on the other. Therefore, the pump 48 is arranged to select its discharging pressure so as to discharge the highly viscous material fed to the discharging device 10 at a high speed.

When it is desired that the hollow bead is tacky or adhered to a work 23 of a control board as in this embodiment, a highly viscous material having an tackinessly or adhesive property is selected for a portion where they
5 are to be tackied or adhered to the work 23 when cured, while a highly viscous material having no tackinessly or adhesive property is selected for a portion where they are not to be tackied or adhered thereto. It is also possible to use a highly viscous material having no tackinessly or
10 adhesive property, however, when a applying position of the work 23 is pre-applied with an adhesive and then the highly viscous material is discharged onto the applying position thereof with the adhesive pre-applied thereon.

The gas feed section 14 of Fig. 1 may be showed the
15 gas feed device 14, for example, as indicated in Fig. 6. The nitrogen gas feed device 14 may consist of an input port 140 through which compressed air is fed, an electromagnetic valve 142 capable of adjusting a flow rate of the compressive air to be fed on the basis of a
20 pressure value measured by a manometer 144, a filter 148, a manometer 146 for measuring a pressure of nitrogen gas passing through the filter 148, a membrane module 150 capable of permeating nitrogen gas at a slower membrane permeability while discharging hydrogen, oxygen and other
25 gases at a faster membrane permeability, a pressure reducing valve 151 for reducing a pressure value of the nitrogen gas permeated through the membrane module 150 on the basis of the pressure value measured by a manometer 152,

an oxygen sensor 153 for sensing oxygen O₂ from the gases permeated through the membrane module 150, a flow meter 154 for measuring a flow rate of the nitrogen gas, a needle valve 155 for controlling the discharging of the separated nitrogen gas, and a discharging port 156 for discharging the nitrogen gas. As described above, the nitrogen gas feed device 14 has a very simplified structure of a membrane separation type, so that nitrogen gas can readily be separated and generated from compressive air fed.

It is preferred to adjust the pressure of the gases to be fed from the gases feed section 14 to a pressure level somewhat higher than atmospheric pressure. Further, the gases feed section 14 may also include, for example, a system for feeding air or other gases as well as nitrogen gas.

Then, a description will be made regarding the action of the structure according to the first embodiment of the present invention with reference to the accompanying drawings.

The work 23 for control boards loaded on the belt 67 of the belt conveyor 65 at predetermined intervals are transferred one after another (e.g., in the direction perpendicular to the drawing paper plane of Fig. 1) into an area where the manipulator 60 can be moved. Before operating the step of discharging the highly viscous material, the discharging device 10 is located in a waiting position such that the tip of the rod 19 is engaged with the valve path 28 by the compressive air control of the

compressive air control section 18 and the highly viscous material fed from the highly viscous material feed section 16 is stored in the material chamber 27. On the other hand, the gas control valve 11c is closed so that the gases
5 discharged from the gases feed section 14 are not yet fed to the discharging device 10.

As the detection sensor 25 detects that the work 23 is carried to the predetermined position, the operation of the belt conveyor 65 is temporarily stopped. Then, the
10 controller 22 controls the manipulator 60 so as to transfer the discharging device 10 to the position right above the predetermined applying position of the work and direct the nozzle 12 downward directly to the predetermined applying position thereof. Thereafter, the compressive air control
15 section 18 is controlled so as to release the rod 19 from the valve path 28 and to open the gas control valve 11c.

Once the gas control valve 11c is opened, the gases are discharged directly downward from the tip of the inner nozzle 36 through the inner gas path 30 and the gas nozzle
20 line 32 by the aid of the feed pressure from the gases feed section 14, thereby forming gases stream flowing in the one direction. On the other hand, the highly viscous material within the material chamber 11a are also discharged directly downward from the tip of the outer nozzle 38
25 through the inner material path 29 and the material nozzle line 31 enclosing the inner nozzle by the aid of the feed pressure from the highly viscous material feed section 16. This creates a flow of the highly viscous material stream

in a high speed flow region in substantially the same flow direction as the flow of the gas stream in an outer peripheral space about and enclosing the gases stream flowing in the one direction.

5 The controller 22 controls the manipulator 60 so as for the discharging device 10 to be movable on the plane (i.e., the plane parallel to the surfaces of the work 23) perpendicular to the discharging direction along a predetermined applying position 56 of the work 23 (e.g., a
10 site nearby the entire circumference of an edge portion of the lid plate 23 as shown in Fig. 8(a)) in such a state that the discharging device 10 is discharging the gases and the highly viscous material from the nozzle 12.

 While the highly viscous material is being discharged
15 directly downward to the predetermined applying position of the work 23 from the nozzle 12, the speed of the flow of the highly viscous material stream is in a high speed flow region by the aid of the feed pressure from the highly viscous material feed section, as shown in Fig. 7(a).

20 Therefore, the bead can be molded in a flexible manner by reducing a loss in pressure within the flow passage because of the low dynamic viscosity of the highly viscous material and by transferring the nozzle. However, as the flow of the highly viscous material stream has struck the top
25 surface of the predetermined applying position of the work 23, for example, the flow speed of the highly viscous material stream in the high speed flow region is rapidly decreased to a low speed and eventually to zero. Therefore,

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the static viscosity of the highly viscous material stream is caused to increase so high that the highly viscous material is allowed to stay in the shape on the predetermined applying position into which the material

5 has been applied and molded in the low speed flow region, i.e., in the shape which it has held as it struck the predetermined applying position on the work 23. In other words, the highly viscous material stream holds the shape in a concentrically circular form with the gas stream, when

10 looked in section, in such a manner that the highly viscous material stream is located outside about and enclosing the gas stream. Further, as the nozzle 12 is transferred along the applying position while maintaining this state, the highly viscous material is applied and molded into the

15 given shape on the work 23 along the shape of the predetermined applying position thereof. In other words, the highly viscous material is set into the shape into which it is discharged on the predetermined applying position of the work 23.

20 When a highly viscous material of a cold-setting type is used, it is set continually as the time elapses while maintaining the shape as it has been applied. On the other hand, when a highly viscous material of a heat-setting type is used, a heating step of heating the highly viscous

25 material applied has further to be added to the step of applying and molding the highly viscous material.

Fig. 7(b) shows a hollow bead applied and molded into a shape in the manner as described above. As shown in Fig.

7(b), a hollow bead 54 in tubular form is shown having a hollow portion 52 formed therein with a gas path left hollow and an outer peripheral portion 53 formed about and enclosing the hollow portion 52. The hollow bead 54 is
5 molded by discharging the gases flowing stably through the central portion thereof and the highly viscous material flowing stably about and enclosing the outer periphery of the gas stream from the nozzle 12 of a double nozzle configuration. Therefore, the hollow bead applying and
10 molding method according to the present invention can provide the hollow bead of high quality in a stable manner.

The hollow bead 54 can also be molded into the shape in section corresponding to the sectional shape of the nozzle 12 of the discharging device 10. As each of the
15 inner nozzle 36 and the outer nozzle 38 in this embodiment is in the form of a concentric circle as shown in Fig. 3, the sectional shape of the bead 54 is likewise in the form of a concentric circle corresponding to the sectional shape of each of the nozzles 36 and 38. It is to be noted herein
20 as a matter of course that the sectional shape of the bead 54 can be varied in optional and appropriate manner by optionally varying the sectional shape of each of the nozzles.

The controller 22 can control the manipulator 60 in
25 the procedures as described above so as to apply and mold the hollow bead following and along the entire periphery of a applying position 56 (Fig. 8(a)). Upon molding and applying the bead, a CCD sensor 25 picks up an image of the

applied hollow bead, and the image data is always transmitted to the controller 22 through the I/O port 20. The controller 22 extracts an outline of the tip portion of the actually applied hollow bead by analyzing the received
5 image data at a real time, and calculates the applying position at the current time. Then, the applying position as a target time pre-stored in the memory unit 24 is retrieved, and a deviation between the actual applying position calculated and the target applying position
10 retrieved is calculated. Thereafter, the manipulator 60 is controlled in accordance with the predetermined control algorithm (e.g., PI control, etc.) so as to adjust the accurate discharging position of the nozzle 12 by adjusting this deviation to substantially zero.

15 Finally, as shown in Fig. 8(b), the hollow bead 57 is applied and molded accurately over the entire periphery close to the edge portion of the work 23. Furthermore, the discharging of the discharging device 10 is stopped and then the belt conveyor 65 is re-started ready for the next
20 procedures and transfers another work 23 loaded next to the work 23 previously processed to the applying position. The like procedures are repeated until all the work 23 have been applied and molded.

In the method in this embodiment, it may be possible
25 to automatically decide whether one work 23 has been applied and molded in a complete and favorable manner as it has been covered with the hollow bead 57. For instance, the CCD sensor 26 picks up an entire image of the hollow bead

57 applied thoroughly, and the image data is transmitted to the controller 22. The controller 22 detects an entire outline of the hollow bead 57 by analyzing the image data received, and a feature pattern is extracted. Then, a
5 reference feature pattern of a hollow bead accurately applied, which has been pre-stored in the memory unit 24, is retrieved, and the feature pattern of the actually applied hollow bead is compared with the retrieved reference feature pattern of the hollow bead to determine a
10 degree of similarity. If it is decided that the degree of similarity exceeds a predetermined value, then the hollow bead applied is determined as no good. On the other hand, if it is decided that the degree of similarity is below the predetermined value, the hollow bead applied is determined
15 as good. These decision results may be displayed on a display unit or any other suitable unit (not shown). Therefore, the operator can take the necessary measures as soon as possible in accordance with the decision results displayed on the display unit, etc.

20 In the embodiment of the present invention, although the work 23 is curved at the corners thereof, the hollow bead 57 can be readily applied and molded at a curved portion, e.g., at the corners thereof, because the hollow bead 57 is made of the highly viscous material that is
25 fluid and flows in a high speed flow region during applying. Moreover, the hollow bead 57 can maintain the configuration in which the gas stream is flowing at the central portion thereof and the highly viscous material stream is flowing

about and enclosing the gas stream, so that even a curved hollow bead by curved the high viscous material of high quality can also be molded with ease. Therefore, the hollow bead can readily be molded into any optional and
5 suitable shape. In other words, in this embodiment, the hollow bead can readily be applied and molded into an irregular shape, while sustaining high quality, due to fluidity of the highly viscous material in a high speed flow region, flow stability, and ability of retaining the
10 shape into which the bead is molded in a low speed flow region.

In addition, the hollow bead 57 can provide a sealing section with appropriate flexibility because it is lightweight and low in stress upon compression due to the
15 hollow configuration within the bead. This presents the merits that sealing properties of an opening/closing member can be improved, for example, when the control board is closed with the lid 23 and that the operations for opening and closing the lid can be conducted with ease due to the
20 lightweight material. This embodiment of the present invention can realize the hollow bead applying and molding system 1 having the above merits in simple structure as shown in Figs. 1 to 6.

Second Embodiment:

25 In the second embodiment, a foamed bead is used, in place of the hollow bead used in the first embodiment, and the foamed bead comprises a foamed body with the inside formed into a tubular shape and the outer periphery applied

with a highly viscous material. The same elements of the foamed bead in this embodiment are provided with the same numerical references and symbols as those in the first embodiment, and a duplicate description is omitted for
5 brevity of explanation.

Fig. 9 shows an overall configuration of an automatically applying and molding system 2 in accordance with the second embodiment of the present invention. The automatically applying and molding system 2 in this embodiment is configured such that the gases feed section 14 used in the first embodiment is replaced with a foamable material feed section 14b that feeds a foamable material for forming a foamed body by foaming gases upon discharging.

In order to adapt this modification to discharging the foamable material, the discharging device 10 in the first embodiment may be modified to a discharging device 10b in the second embodiment. For instance, the discharging device 10b may include a feed inlet for feeding the foamable material and a control valve disposed in the feed inlet, and the inner configuration of the nozzle 12b, particularly a path of the inner nozzle or the like, is modified in a favorable fashion as a path for feeding the foamable material. However, the structure of the second embodiment is basically equal to that of the first embodiment, so that a detailed illustration of the discharging device 10b is omitted in the accompanying drawings.

When the foamable material is fed in the form of a

mixture of gases with the highly viscous material, the foamable material feed section 14b may be modified into the structure as shown in Fig. 10. The foamable material feed section 14b may include a gases feed unit 237A, a highly viscous material feed unit 237B, a mixing unit 237C, and a dispersing unit 237D.

The gases feed unit 237A feeds gases at pressure in a predetermined range as low as from approximately 0.1 to 5 Kg/cm³, preferably from approximately 0.1 to 3 Kg/cm³. In this embodiment, a nitrogen gas generator of a known configuration may be used, which is arranged to separate nitrogen gas from compressed air by a membrane separation system. The gases feed unit 237A may comprise, for example, a port 231 for receiving compressed air from a compressor (not shown), a filter 232, a membrane separation module 233, a pressure regulating valve 234, a gas flow meter 235, and a tubular path 239A for feeding separated nitrogen gas.

The highly viscous material feed unit 237B may comprise a plunger pump 242A for discharging the highly viscous material stored in the storage can at a constant flow amount, a motor 230 for driving the pump 242A, and a tubular path 239B through which the discharged highly viscous material flows.

The mixing unit 237C may include two piston pumps 245A and 245B, each of which conducts the suction stroke and the extrusion stroke by reciprocally moving the piston in the cylinder. The piston rod of each of the piston pumps 245A and 245B is connected to motors 236A and 236B,

respectively, which reciprocally drive the pistons in a linear way.

The tubular path 239A of the gases feed unit 237A is branched into two tubular path branches, one tubular path branch being connected to the position close to the top dead center of the piston pump 245A through a control valve V1 and the other tubular path branch being connected to the position close to the top dead center of the piston pump 245B through a control valve V2. Further, the tubular path 239B of the gases feed unit 237B is branched into two tubular path branches, one tubular path branch being connected to the position close to the bottom dead center of the piston pump 245A through a control valve V3 and the other tubular path branch being connected to the position close to the bottom dead center of the piston pump 245B through a control valve V4. In other words, the piston pumps 245A and 245B are configured to introduce the highly viscous material fed from the highly viscous material feed unit 237B and the gases fed from the gases feed unit 237A, respectively, at a predetermined rate in a batch manner. It is to be understood herein that the term "bottom dead center" of the piston pump referred to herein means the stroke end section of the extrusion stroke and the term "top dead center" of the piston pump referred to herein means the stroke end section of the suction stroke.

Furthermore, the piston pumps 245A and 245B are each provided with a discharging tubular path for discharging a mixture obtainable by mixing gases with the highly viscous

material in the cylinder, which extends from the stroke end
section of the extrusion stroke. The discharging tubular
paths are further provided with valves V5 and V6 as well as
check valves CV5 and CV6, respectively, and they are then
5 united into a tubular path 239C.

The operations of the piston pumps 245A and 245B of
the mixing unit 237C and the valve system are controlled in
accordance with a timing chart as shown in Fig. 11. It is
to be noted herein that the piston pumps 245A and 245B are
10 operated such that the extrusion stroke of each piston pump
does not overlap with each other. As indicated in the
timing chart of Fig. 11, the gases are introduced into the
cylinder by the suction stroke, and the highly viscous
material under a high pressure is allowed to be fed while
15 the piston is positioned at the stroke end section of the
suction stroke. Then, a mixture of the gases with the
highly viscous material is discharged by the extrusion
stroke. In this case, the gases are compressed by the
highly pressurized highly viscous material subsequently
20 filled therein to the volume that can be regarded as
negligible, so that the highly viscous material can be
mixed with the gases in the amount substantially equal to
the cylinder volume. This can readily lower the pressure
of the gases to be fed into the cylinder and control a
25 mixing ratio of the gases to the highly viscous material by
adjusting the pressure of the gases to be fed.

The tubular path 239C is connected to a discharging
tubular path 244 through the dispersing unit 237D that in

turn may include a pressurizing device 241 composed of a piston pump, etc. and a dispersing tubular path 243. The pressurizing device 241 then pressurizes the mixture fed while flowing through the tubular path 239C, and the
5 mixture under pressure is introduced into the dispersing tubular path 243. While the mixture is passing through the dispersing tubular path 243, gaseous bubbles are dispersed in more minute form in the highly viscous material. Then, the minutely dispersed gaseous bubbles are expanded as the
10 mixture is released into atmospheric pressure upon discharging, thereby forming a foamed body.

Then, the action of the second embodiment of the present invention will be described. A description will be given regarding the action part only, which is different
15 from the action of the first embodiment, and a description of the equal and like action part of the first embodiment will be omitted from the following explanation.

In the second embodiment, the discharging device 10b is disposed so as to move along the applying position of
20 the work 23 while discharging the highly viscous material from the outer nozzle 38, on the one hand, and the foamable material in the form of a mixture of gases with the highly viscous material from the inner nozzle 36, on the other, toward the applying position thereof. At this time, a flow
25 of the foamable material stream in the one direction is formed, while a flow of the highly viscous material in a high speed flow region in the same direction is formed within an outer peripheral space outside and about the

foamable material stream. As the highly viscous material stream is discharged about and enclosing the foamable material stream and reaches the applying position of the work 23, the high speed flow of the highly viscous material stream is dropped to the low speed flow and eventually zero and the highly viscous material stream is applied on the applying position of the work 23 and molded into the shape corresponding to the shape of the applying position thereof. On the other hand, the foamable material stream is discharged and allowed to foam into a foamed body upon exposure to atmosphere. The foamed body is filled in the inside of the highly viscous material while sustaining its shape, and molded into the shape corresponding to the shape of the inner wall made of the highly viscous material. Then, the highly viscous material and the foamed body are allowed to cure, while sustaining the shape as it was before curing.

In the second embodiment, there is obtained the foamed tubular bead with the inside filled with the foamed body and with the outside composed of and covered with the highly viscous material (as shown in Fig. 7(b), however, the hollow portion 52 of the hollow bead 54 being replaced with the foamed body).

As the foamed bead is also a foamed body with the inside rich with gases bubbles, it is lightweight and requires a small amount of stress upon compression, thereby providing a sealing section having an appropriate degree of flexibility and softness. Therefore, the foamed bead can

present the benefits that it provides the lid 23 of a control board with improved sealing performance when closed and that operations of opening and closing the lid 23 are conducted with ease particularly due to its light weight.

5 Moreover, the foamed bead according to this embodiment can provide with the resulting foamed body with improved waterproof performance, airtight performance, shock absorbing performance, and so on, as compared with a bead of a foamed body covered with no highly viscous
10 material.

Third Embodiment:

 The third embodiment is directed to a bead molding apparatus capable of manually applying and molding a hollow bead or a foamed bead on a desired site, rather than an
15 automatically applying system suitable for a large-scale production in accordance with the above embodiments.

 Fig. 12 shows a bead molding apparatus according to the third embodiment. The same and like elements are provided with the same reference numerals and symbols as
20 those in the first and second embodiments, and a duplicate description of the same and like elements will be omitted for brevity of explanation.

 The discharging device 10c of Fig. 12 is substantially equal in structure to the discharging device
25 10 of the first embodiment and the discharging device 10b of the second embodiment. In this embodiment, the discharging device 10c is arranged in such a manner that the gas or the foamable material is discharged from the

inner nozzle and the highly viscous material is discharged from the outer nozzle, thereby applying and molding the hollow bead or the foamed bead. The discharging device 10c has a grip portion 167 with a discharging switch 167 and
5 can control the opening and closing of a control valve disposed in a path for feeding the gas or the foamable material and a control valve disposed in a path for feeding the highly viscous material by turning the discharging switch 167 on or off.

10 As shown in Fig. 12, a bead molding device 160 is disposed on a carrier 161 with a caster 162, and comprises a feed device 163 for feeding each of gases or the foamed material and the highly viscous material, a mounting seat 164 disposed extending from the side of a housing of the
15 feed device 163, the discharging device 10c disposed detachably on the mounting seat 164 through the grip portion 167, and a bundle of hoses 168 connecting the discharging device 10c to the feed device 163.

The bead molding device 160 allows the operator to
20 apply a desired site with the hollow bead or the foamed bead.

As have been described above, the present invention has been explained by way of the embodiments. It is to be noted herein, however, that the present invention is not
25 limited in any respect to those embodiments and that any modifications or variations are encompassed without departing from the scope and spirit of the present invention.

Although the hollow tubular bead covered with the highly viscous material is molded in the first embodiment, the present invention can be extended to a system for molding the hollow bead covered with a tubular foamed body.

5 This extension can be readily realized by replacing the highly viscous material feed unit 16 of the bead applying and molding system 1 of Fig. 1 with the highly viscous material feed unit of Fig. 10.

10 In the above embodiments, controlling the speed of the flow of the highly viscous material stream or the foamable material stream varies the fluidity of the highly viscous material stream or the foamable material stream. It is also possible to use a hot melt material and a foamable hot melt material, the hot melt material being
15 fluid when it is in the form of a stream in a middle-high temperature region and high in the ability to retain the shape into which it is molded when it is in the form of a stream in a middle-low temperature region, and the foamable hot melt material being obtainable by foaming such a hot
20 melt material. When the hot melt material is used, it is heated before applying to increase its fluidity and to increase the ability to retain the shape into which the material is allowed to cool immediately before applying or after applying.

25 Further, in the first and second embodiments, the lid for the control board is used as an object to be applied and molded. It is to be noted herein that the present invention is not limited to this object and can be applied

to, for example, an opening and closing member for closing an arbitrary opening portion, e.g., a window glass, plastic glass, plastic plate, metallic door, or any other appropriate object, and to a site requiring waterproof, airtight, and shock-absorbing performance, e.g., an engagement section, a clearance section, and so on.

Moreover, in the above embodiments, the bead is applied over the entire periphery of the opening and closing member. The present invention is not limited to this way of applying and it may encompass the case within the scope of the invention, which is directed to applying the bead partially on a portion alone, when only the portion of the periphery of an opening and closing member is attached to an opening portion. In other words, the present invention can vary the applying position in an appropriate and optional way in accordance with the object, i.e., an opening and closing object, etc.

Furthermore, the present invention is not limited to the specific method for applying and attaching the bead to a predetermined applying object, as described above, and it can be applied to the case where the hollow bead or the foamed bead is molded using a highly viscous material of a non-adhesive property. For instance, it is also possible to prepare a product made of a bead only which is not tackied to any member by molding an elongated bead while winding the discharged and molded bead on a rotary roller or the like and cutting to a desired length after separating the molded bead from the roller.

In addition, in the second embodiment, the mixture of the gases with the highly viscous material is used as the foamable material. The present invention, however, is not limited to the use of the mixture and it may be applied to
5 the use of a highly viscous material of a heat-foamable type or a two-liquid foamable material, for example.

Further, in the above embodiments, there is used the mixture feed device 50 with the cylinder pump as a system for mixing the gases with the highly viscous material. The
10 present invention, however, is not limited to this particular mixing system and may include, for example, a stirring-mixing unit such as a mixer and so on.